

**2008 SUMMARY REPORT
of
Bangs Lake**

Lake County, Illinois

Prepared by the

**LAKE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH SERVICES
LAKES MANAGEMENT UNIT**

3010 Grand Avenue
Waukegan, Illinois 60085

Kelly Deem
Michael Adam
Leonard Dane
Kathleen Paap

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- Appendix A. Methods for field data collection and laboratory analyses.
- Appendix B. Multi-parameter data for Bangs Lake in 2008.
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- Appendix D. Water quality statistics for all Lake County lakes.
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LAKE FACTS

Lake Name:	Bangs Lake
Historical Name:	None
Nearest Municipality:	Village of Wauconda
Location:	T44N, R9E, Sections 24, 25, and 26
Elevation:	766.2 feet above mean sea level
Major Tributaries:	Slocum Lake Drain
Watershed:	Fox River
Sub-watershed:	Slocum Lake Drain
Receiving Waterbody:	Slocum Lake
Surface Area:	306.1 acres
Shoreline Length:	6.3 miles
Maximum Depth:	32.0 feet
Average Depth:	10.9 feet
Lake Volume:	3,323.6 acre-feet
Lake Type:	Glacial
Watershed Area:	3,027.0 acres
Major Watershed Land Uses:	Single Family and Agricultural
Bottom Ownership:	Private, Public (Village of Wauconda)
Management Entities:	Village of Wauconda
Current and Historical Uses:	Swimming, fishing, boating.
Description of Access:	All access locations are private, open to the public (with a permit sticker).

In 2005, Bangs Lake was chosen to be one of seven “sentinel” lakes in the county the Lakes Management Unit (LMU) will monitor annually for five years. This report summarizes the water quality sampling results and aquatic plant surveys conducted in 2008 on Bangs Lake. Similar reports have been written on data collected in 1997, 2002, and 2005 through 2008; these reports are available online from the LMU (<http://www.lakecountyil.gov/Health/want/LakeReports.htm>). 2009 will be the final year of the annual “sentinel” lake monitoring. A comprehensive summary report detailing all five years will be completed and available for review in 2010.

SUMMARY OF WATER QUALITY

Water samples were collected from April to November in Bangs Lake at the deepest point near the center of the lake (Figure 1). Samples were taken at three feet below the surface and approximately three feet above the lake bottom (Appendix A). Water level was taken from the staff gauge at the park district launch. The water level ranged from 1.96 inches in April and 1.19 inches in September. Water level decreased in May and rose in June and July, then decreased in August but rose again with the rains in September. There was an overall decrease of 0.77 inches for the season.

Bangs Lake has exceptional water quality (Appendix C) with many parameters below the county medians. The lake nutrient concentrations remained relatively stable or have improved since 2002. Total suspended solid (TSS) concentrations averaged 1.8 mg/L in 2008, which is more than four times lower than the county median (8.2 mg/L) and lower than in 2007, 2006, and 2005 (2.2 mg/L, 2.3 mg/L, and 3.4 mg/L, respectively). High TSS values are typically correlated with poor water clarity (Secchi disk depth) and can be detrimental to many aspects of the lake ecosystem such as the plant and fish communities. As a result of low TSS concentrations, the average Secchi depth for the season (14.09 feet) was much higher than the county median (3.12 feet; Figure 2). Bangs Lake participates in the Volunteer Lake Management Program (VLMP); The VLMP Secchi depth averages over the past four years have been between 10.30 feet and 11.33 feet. The VLMP data from 2005 through 2008 had an average Secchi depth of 11.10 feet while the LMU average from 1997 through 2008 was 11.81 feet. (Figure 3). Differences between VLMP and LCHD data can be attributed to discrepancies between samplers, as well as date and time samples were taken. LMU Secchi disk readings far surpassed the county median in 2007, 2006, and 2005 as well, with an average of 14.12, 12.76, and 13.76 feet, respectively. Although the increase in water clarity is perceived as good, it most likely is due to the presence of Zebra Mussels in the lake. Exotic Zebra Mussels are filter feeders and the long term affects are not completely known. Signage was posted at all boat launches in 2008 informing lake users of the presence of Zebra Mussels to prevent their spread to other lakes.

Stratification is typical of nutrient-enriched deep lakes like Bangs Lake. When stratified, the lower and upper layers of water do not mix, and the lower layer typically becomes anoxic (dissolved oxygen <1 mg/L). Nutrient concentrations were slightly higher in the lower layer than in the upper layer, which is expected in a stratified lake. The lake was only stratified in June through August of 2008. Dissolved oxygen (DO) concentrations became anoxic in the hypolimnion June through August. The maximum volume experiencing anoxia was approximately 6.1% in June and August (DO concentrations <1.0 mg/L below 24 feet in July), thus there are no apparent DO problems in Bangs Lake (Appendix B). Concentrations >5.0

mg/L are considered adequate to support aquatic life, since some aquatic life, such as fish, suffer from oxygen stress below this amount.

Phosphorus is a nutrient that limits plant and algal growth, therefore any addition of phosphorus to the lake would likely produce algal blooms. Total phosphorus (TP) in the epilimnion of Bangs Lake has remained relatively stable over the years. In 2007 and 2006 it averaged 0.022 mg/L (Table 1), the 2008 value decreased slightly (0.020 mg/L) which is nearly a third of the county median (0.065 mg/L) (Appendix D). Nitrogen is the other nutrient critical for algal growth. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen, and is typically bound up in algal and plant cells. The average TKN for Bangs Lake was 0.70 mg/L, which was lower than the county median of 1.2 mg/L, and slightly lower than in 2007, 2006, and 2005 (0.89 mg/L, 0.85 mg/L, 0.83 mg/L respectively). The TN:TP (total nitrogen to total phosphorus) ratio looks at which nutrient is limiting plant and algal growth in a lake. Bangs Lake had a TN:TP ratio of 43:1 which indicated phosphorus was highly limiting. A general overall index that is commonly used is called a trophic state index (TSI). This index can be calculated using total phosphorus values obtained at or near the surface. In 2008 Bangs Lake was mesotrophic with a TSIp value of 44.8. Bangs Lake ranked 8th of 163 lakes in the county based on TSIp (Table 2). In 2007, Bangs Lake was also classified as mesotrophic with a TSIp of 48.2.

Another index used by the Illinois Environmental Protection Agency (IEPA) for assessing lakes for aquatic life and recreational use impairment is calculated using the mean TSIp, percent macrophyte coverage, and the median nonvolatile suspended solids concentration. This index can be calculated using total phosphorus values obtained at or near the surface. In 2008 Bangs Lake had *Full* support for aquatic life, recreational use, and total overall use. The use support was the same for 2007 and 2006, however in 2005, the recreational use was classified as *Partial*.

Conductivity readings in Bangs Lake increased slightly from 2005-2007 (Table 3). The 2008 average conductivity was 0.6138 milliSiemens/cm, which was slightly lower than the 2005-2007 values, and still below the county median of 0.8195 mS/cm. One of the most common dissolved solids is road salt used in winter road maintenance. Because of the high conductivity readings with in Lake County, one additional parameter, chlorides, was collected. Chloride concentrations help determine if road salt is the primary chloride source as most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts. The seasonal average for chlorides in Bangs Lake in 2008 was 102 mg/L in the epilimnion and 101 mg/L hypolimnion. The chloride concentration is the same as 2007. However, the chloride concentration is up from 2005 (99 mg/L), which is a common trend in Lake County Lakes. The Village of Wauconda is encouraged to pursue alternatives to road salt.

Figure 1. Water quality sampling site on Bangs Lake, 2008.



Figure 2. Secchi depth vs. total suspended solid (TSS) concentrations in Bangs Lake, 2008.

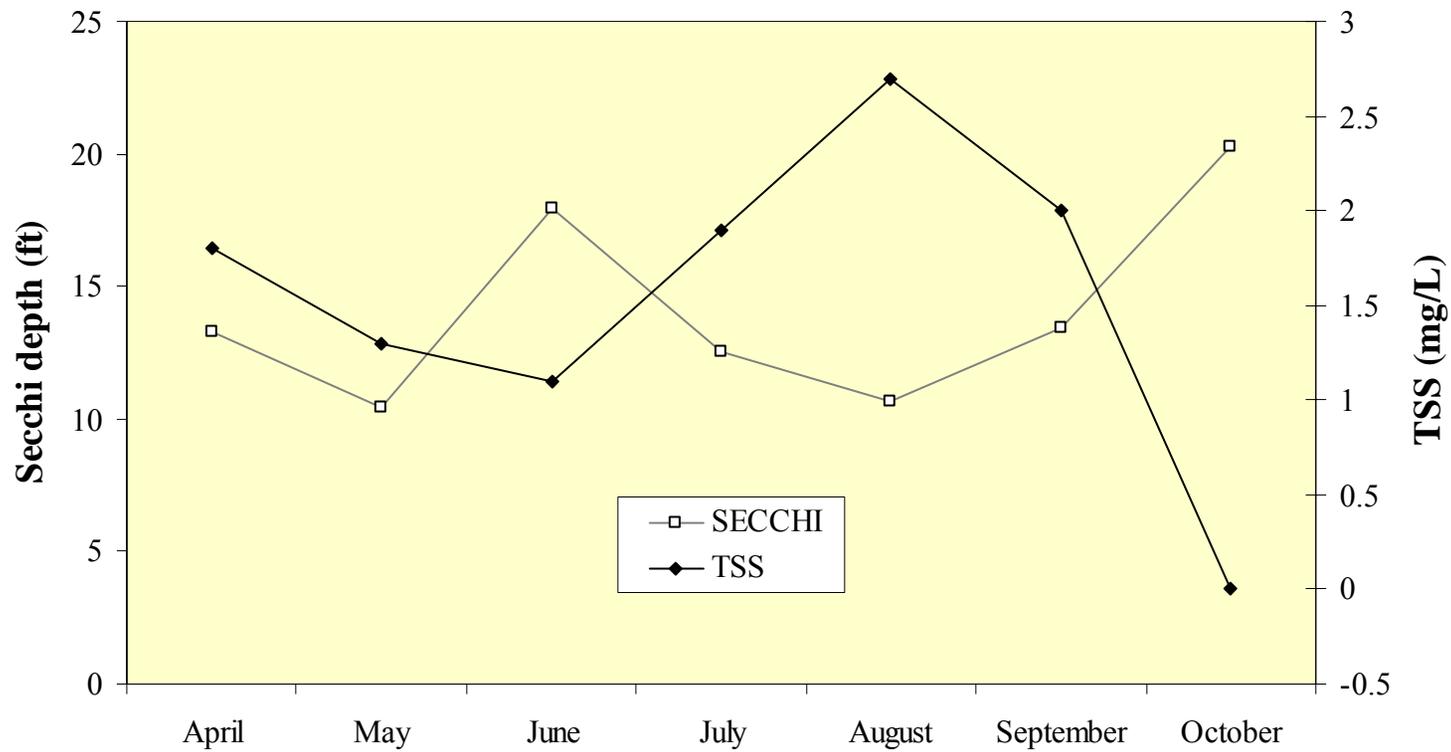


Figure 3. Secchi disk averages from VLMP and LCHD records for Bangs Lake.

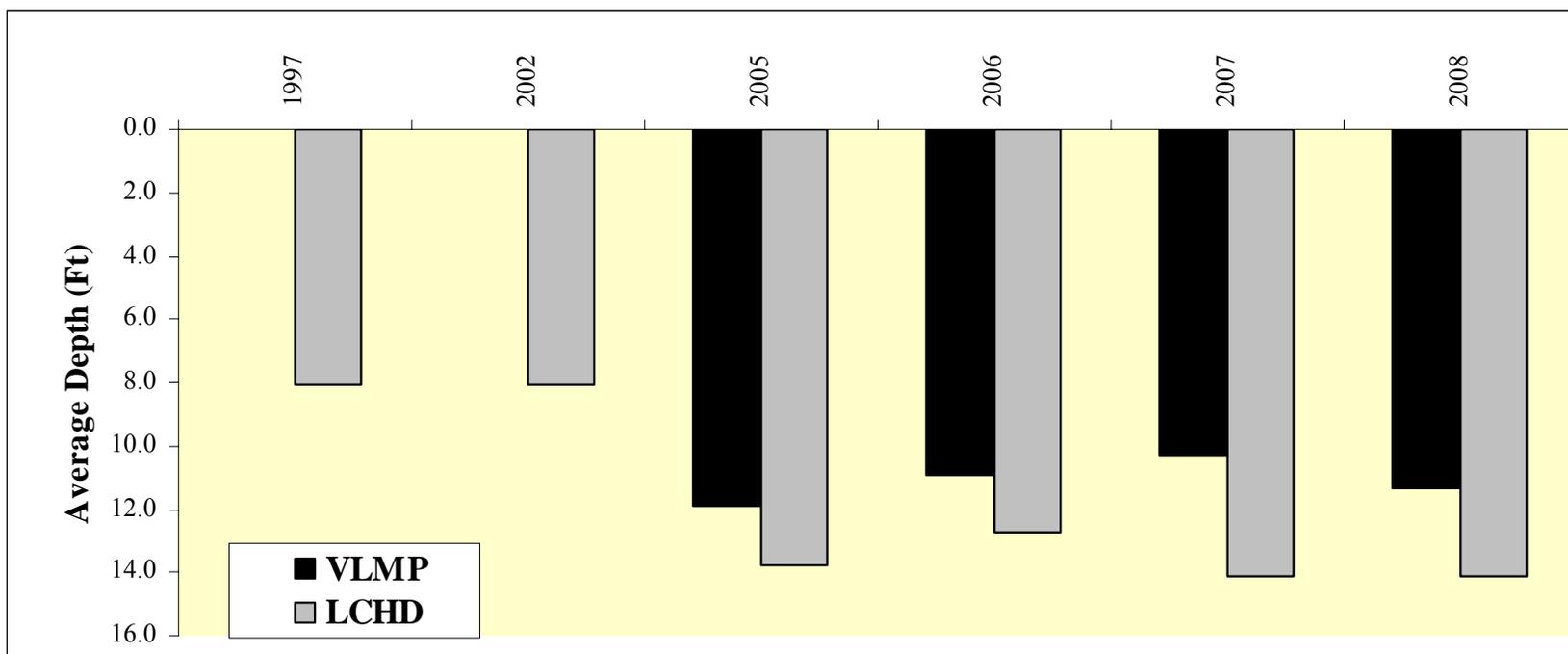


Table 1. Summary of water quality data for Bangs Lake, 2008.

2008		Epilimnion													
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₂ +NO ₃	TP	SRP	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
16-Apr	3	148	0.71	<0.1	0.077	0.018	<0.005	102	1.8	361	74	13.29	0.6299	8.31	11.08
21-May	3	146	0.71	<0.1	<0.05	0.017	<0.005	103	1.3	359	62	10.47	0.6334	8.68	10.95
18-Jun	3	133	0.64	<0.1	<0.05	0.012	0.012	101	1.1	349	72	17.98	0.6109	8.55	8.22
19-Jul	3	131	0.71	<0.1	<0.05	0.018	<0.005	101	1.9	356	79	12.53	0.6095	8.81	9.16
20-Aug	3	132	0.78	<0.1	<0.05	0.028	<0.005	105	2.7	357	86	10.66	0.6205	8.56	8.44
18-Sep	3	132	0.65	<0.1	<0.05	0.024	<0.005	100	2.0	343	69	13.45	0.5966	8.17	7.88
5-Nov	3	138	0.72	<0.1	<0.05	<0.01	<0.005	101	<1	354	73	20.24	0.5958	8.18	10.47
Average		137	0.70	<0.1	<0.05	0.020 ^k	0.012 ^k	102	1.8 ^k	354	74	14.09	0.6138	8.47	9.46
2007		Epilimnion													
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₂ +NO ₃	TP	SRP	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
10-Apr	3	148	0.75	<0.1	<0.05	0.017	<0.005	104	<1	374	74	21.33	0.6369	8.34	12.22
15-May	3	149	0.76	<0.1	<0.05	0.015	<0.005	104	<1	382	81	17.88	0.6410	8.55	9.48
19-Jun	3	140	0.83	<0.1	<0.05	0.019	<0.005	105	2.3	367	88	15.42	0.6362	8.48	7.31
17-Jul	3	141	1.12	<0.1	<0.05	0.025	<0.005	107	1.3	362	78	18.04	0.6481	8.26	6.88
14-Aug	3	136	0.82	<0.1	<0.05	0.026	<0.005	103	2.5	364	89	8.27	0.6204	8.31	6.62
18-Sep	3	141	0.81	<0.1	<0.05	0.025	<0.005	97	3.6	362	85	8.20	0.6003	8.30	8.58
23-Oct	3	145	0.85	<0.1	<0.05	0.025	<0.005	97	2.9	352	86	9.68	0.5583	8.01	8.06
Average		143	0.85	<0.1	<0.05	0.022	<0.005	102	2.5	366	83	14.12	0.6202	8.32	8.45
2006		Epilimnion													
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₂ +NO ₃	TP	SRP	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
12-Apr	3	147	0.86	<0.1	0.059	0.021	<0.005	107	2.8	371	72	10.50	0.6412	8.23	10.54
17-May	3	136	0.86	<0.1	<0.05	0.024	<0.005	107	1.4	359	81	21.20	0.6222	8.04	9.08
21-Jun	3	126	0.82	<0.1	<0.05	0.024	<0.005	108	1.5	359	91	13.94	0.6129	8.91	6.88
19-Jul	3	124	0.88	<0.1	<0.05	0.018	<0.005	108	2.4	353	79	9.12	0.6140	8.80	7.59
16-Aug	3	125	0.95	<0.1	<0.05	0.024	<0.005	110	3.5	364	87	6.03	0.6186	8.75	7.82
20-Sep	3	129	0.99	<0.1	<0.05	0.023	0.005	106	3.1	358	82	6.72	0.6162	8.52	7.94
1-Nov	3	137	0.87	<0.1	<0.05	0.020	<0.005	106	1.5	366	89	21.82	0.6141	8.16	10.25
Average		132	0.89	<0.1	0.008 ^k	0.022	0.005 ^k	107	2.3	361	83	12.76	0.6199	8.49	8.59

Glossary

ALK = Alkalinity, mg/L CaCO ₃	Cl ⁻ = Chloride ions, mg/L
TKN = Total Kjeldahl nitrogen, mg/L	TSS = Total suspended solids, mg/L
NH ₃ -N = Ammonia nitrogen, mg/L	TS = Total solids, mg/L
NO ₃ -N = Nitrate + Nitrite nitrogen, mg/L	TVS = Total volatile solids, mg/L
TP = Total phosphorus, mg/L	SECCHI = Secchi Disk Depth, ft.
SRP = Soluble reactive phosphorus, mg/L	COND = Conductivity, milliSiemens/cm
TDS = Total dissolved solids, mg/L	DO = Dissolved oxygen, mg/L

NA = Not Applicable
 * = Prior to 2006 only Nitrate was analyzed

Table 1. Continued.

2008		Hypolimnion													
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₂ +NO ₃	TP	SRP	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
16-Apr	24	147	0.70	<0.1	0.07	0.015	<0.005	101	2.5	362	72	NA	0.6297	8.72	11.01
21-May	26	146	0.64	<0.1	<0.05	0.022	<0.005	103	1.8	353	64	NA	0.6345	8.65	9.58
18-Jun	28	151	0.69	0.2	<0.05	0.030	0.011	103	2.4	371	70	NA	0.6505	7.69	0.17
19-Jul	28	163	1.05	0.3	<0.05	0.230	0.108	103	8.1	372	70	NA	0.6667	7.81	0.18
20-Aug	27	171	1.56	0.7	<0.05	0.608	0.168	103	11.0	388	82	NA	0.6722	7.57	0.18
18-Sep	27	132	0.70	<0.1	<0.05	0.023	<0.005	96	2.0	342	76	NA	0.5778	7.93	6.21
5-Nov	23	139	0.65	<0.1	<0.05	<0.01	<0.005	101	<1	351	81	NA	0.5955	8.10	10.36
Average		150	0.86	0.2 ^k	0.07 ^k	0.155 ^k	0.096 ^k	101	4.6 ^k	363	74	NA	0.6324	8.07	5.38
2007		Hypolimnion													
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₂ +NO ₃	TP	SRP	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
10-Apr	26	148	0.65	<0.1	0.05	0.014	<0.005	104	0.0	373	73	NA	0.6370	8.26	11.41
15-May	28	159	0.68	<0.1	<0.05	0.022	<0.005	103	1.5	384	75	NA	0.6593	7.65	0.72
19-Jun	26	166	0.93	0.2	<0.05	0.092	0.048	104	6.0	394	95	NA	0.6761	7.60	0.09
17-Jul	27	183	1.70	0.7	<0.05	0.455	0.131	104	12.0	395	82	NA	0.6985	7.58	0.09
14-Aug	27	176	1.83	0.8	<0.05	0.544	0.128	105	12.0	399	87	NA	0.7066	7.49	0.11
18-Sep	27	141	0.90	<0.1	<0.05	0.035	<0.005	97	4.7	365	91	NA	0.6012	8.17	7.25
23-Oct	27	146	0.83	<0.1	<0.05	0.024	<0.005	98	3.6	353	83	NA	0.5585	8.03	7.93
Average		160	1.07	0.6 ^k	0.05 ^k	0.169	0.102	102	5.7	380	84	NA	0.6482	7.82	3.94
2006		Hypolimnion													
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₂ +NO ₃	TP	SRP	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
12-Apr	20	147	0.78	<0.1	0.06	0.015	<0.005	106	2.8	373	74	NA	0.6409	8.22	10.36
17-May	24	137	0.78	<0.1	<0.05	0.021	<0.005	107	1.2	359	77	NA	0.6233	8.39	7.63
21-Jun	23	155	0.72	<0.1	<0.05	0.027	0.006	106	1.6	369	77	NA	0.6472	7.73	0.31
19-Jul	24	149	0.82	<0.1	<0.05	0.057	0.013	107	6.2	387	90	NA	0.6645	7.63	0.16
16-Aug	24	147	1.43	0.4	<0.05	0.146	0.048	109	7.2	382	97	NA	0.6789	7.49	0.12
20-Sep	23	129	0.96	<0.1	<0.05	0.020	<0.005	108	2.6	348	79	NA	0.6177	8.43	7.02
1-Nov	23	138	0.81	<0.1	<0.05	0.018	<0.005	105	1.0	365	87	NA	0.6139	8.17	10.11
Average		143	0.90	0.4 ^k	0.06 ^k	0.043	0.023 ^k	107	3.2	369	83	NA	0.6409	8.01	5.10

Glossary

ALK = Alkalinity, mg/L CaCO ₃	Cl ⁻ = Chloride ions, mg/L
TKN = Total Kjeldahl nitrogen, mg/L	TSS = Total suspended solids, mg/L
NH ₃ -N = Ammonia nitrogen, mg/L	TS = Total solids, mg/L
NO ₃ -N = Nitrate + Nitrite nitrogen, mg/L	TVS = Total volatile solids, mg/L
TP = Total phosphorus, mg/L	SECCHI = Secchi Disk Depth, ft.
SRP = Soluble reactive phosphorus, mg/L	COND = Conductivity, milliSiemens/cm
TDS = Total dissolved solids, mg/L	DO = Dissolved oxygen, mg/L

Note: "k" denotes that the actual value is known to be less than the value presented.

NA = Not Applicable

* = Prior to 2006 only Nitrate was analyzed

Table 2. Lake County average TSI phosphorous (TSIp) ranking 2000-2008.

RANK	LAKE NAME	TP AVE	TSIp
1	Lake Carina	0.0100	37.35
2	Sterling Lake	0.0100	37.35
3	Independence Grove	0.0135	39.24
4	Lake Zurich	0.0130	41.14
5	Sand Pond (IDNR)	0.0165	41.36
6	West Loon Lake	0.0140	42.21
7	Windward Lake	0.0158	43.95
8	Bangs Lake	0.0170	45.00
9	Pulaski Pond	0.0180	45.83
10	Timber Lake	0.0180	45.83
11	Fourth Lake	0.0182	45.99
12	Lake Kathryn	0.0200	47.35
13	Lake of the Hollow	0.0200	47.35
14	Banana Pond	0.0202	47.49
15	Lake Minear	0.0204	47.63
16	Cedar Lake	0.0220	48.72
17	Cross Lake	0.0220	48.72
18	Sun Lake	0.0220	48.72
19	Dog Pond	0.0222	48.85
20	Stone Quarry Lake	0.0230	49.36
21	Deep Lake	0.0234	49.61
22	Druce Lake	0.0244	50.22
23	Little Silver	0.0250	50.57
24	Round Lake	0.0254	50.80
25	Lake Leo	0.0256	50.91
26	Cranberry Lake	0.0270	51.68
27	Dugdale Lake	0.0274	51.89
28	Peterson Pond	0.0274	51.89
29	Lake Miltmore	0.0276	51.99
30	Third Lake	0.0280	52.20
31	Lake Fairfield	0.0296	53.00
32	Gray's Lake	0.0302	53.29
33	Highland Lake	0.0302	53.29
34	Hook Lake	0.0302	53.29
35	Lake Catherine (Site 1)	0.0308	53.57
36	Lambs Farm Lake	0.0312	53.76
37	Old School Lake	0.0312	53.76
38	Sand Lake	0.0316	53.94
39	Sullivan Lake	0.0320	54.13
40	Lake Linden	0.0326	54.39
41	Gages Lake	0.0338	54.92
42	Honey Lake	0.0340	55.00
43	Hendrick Lake	0.0344	55.17
44	Diamond Lake	0.0372	56.30
45	Channel Lake (Site 1)	0.0380	56.60
46	Ames Pit	0.0390	56.98

Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
47	White Lake	0.0408	57.63
48	Potomac Lake	0.0424	58.18
49	Duck Lake	0.0426	58.25
50	Old Oak Lake	0.0428	58.32
51	Deer Lake	0.0434	58.52
52	Schreiber Lake	0.0434	58.52
53	Nielsen Pond	0.0448	58.98
54	Turner Lake	0.0458	59.30
55	Seven Acre Lake	0.0460	59.36
56	Willow Lake	0.0464	59.48
57	Lucky Lake	0.0476	59.85
58	Davis Lake	0.0476	59.85
59	East Meadow Lake	0.0478	59.91
60	East Loon Lake	0.0490	60.27
61	College Trail Lake	0.0496	60.45
62	Lake Lakeland Estates	0.0524	61.24
63	Butler Lake	0.0528	61.35
64	West Meadow Lake	0.0530	61.40
65	Heron Pond	0.0545	61.80
66	Little Bear Lake	0.0550	61.94
67	Lucy Lake	0.0552	61.99
68	Lake Christa	0.0576	62.60
69	Lake Charles	0.0580	62.70
70	Crooked Lake	0.0608	63.38
71	Waterford Lake	0.0610	63.43
72	Lake Naomi	0.0616	63.57
73	Lake Tranquility S1	0.0618	63.62
74	Wooster Lake	0.0620	63.66
75	Countryside Lake	0.0620	63.66
76	Werhane Lake	0.0630	63.89
77	Liberty Lake	0.0632	63.94
78	Countryside Glen Lake	0.0642	64.17
79	Lake Fairview	0.0648	64.30
80	Leisure Lake	0.0648	64.30
81	Tower Lake	0.0662	64.61
82	St. Mary's Lake	0.0666	64.70
83	Mary Lee Lake	0.0682	65.04
84	Hastings Lake	0.0684	65.08
85	Spring Lake	0.0726	65.94
86	ADID 203	0.0730	66.02
87	Bluff Lake	0.0734	66.10
88	Harvey Lake	0.0766	66.71
89	Broberg Marsh	0.0782	67.01
90	Sylvan Lake	0.0794	67.23
91	Big Bear Lake	0.0806	67.45
92	Petite Lake	0.0834	67.94

Table 3. Continued

RANK	LAKE NAME	TP AVE	TSIp
93	Timber Lake (South)	0.0848	68.18
94	Lake Marie (Site 1)	0.0850	68.21
95	North Churchill Lake	0.0872	68.58
96	Grand Avenue Marsh	0.0874	68.61
97	Grandwood Park, Site II, Outflow	0.0876	68.65
98	North Tower Lake	0.0878	68.68
99	South Churchill Lake	0.0896	68.97
100	Rivershire Pond 2	0.0900	69.04
101	McGreal Lake	0.0914	69.26
102	International Mine and Chemical Lake	0.0948	69.79
103	Eagle Lake (Site I)	0.0950	69.82
104	Valley Lake	0.0950	69.82
105	Dunns Lake	0.0952	69.85
106	Fish Lake	0.0956	69.91
107	Lochanora Lake	0.0960	69.97
108	Owens Lake	0.0978	70.23
109	Woodland Lake	0.0986	70.35
110	Island Lake	0.0990	70.41
111	McDonald Lake 1	0.0996	70.50
112	Longview Meadow Lake	0.1024	70.90
113	Lake Barrington	0.1053	71.31
114	Redwing Slough, Site II, Outflow	0.1072	71.56
115	Lake Forest Pond	0.1074	71.59
116	Bittersweet Golf Course #13	0.1096	71.88
117	Fox Lake (Site 1)	0.1098	71.90
118	Osprey Lake	0.1108	72.04
119	Bresen Lake	0.1126	72.27
120	Round Lake Marsh North	0.1126	72.27
121	Deer Lake Meadow Lake	0.1158	72.67
122	Long Lake	0.1170	72.82
123	Taylor Lake	0.1184	72.99
124	Columbus Park Lake	0.1226	73.49
125	Nippersink Lake (Site 1)	0.1240	73.66
126	Echo Lake	0.1250	73.77
127	Grass Lake (Site 1)	0.1288	74.21
128	Lake Holloway	0.1322	74.58
129	Lakewood Marsh	0.1330	74.67
130	Summerhill Estates Lake	0.1384	75.24
131	Redhead Lake	0.1412	75.53
132	Forest Lake	0.1422	75.63
133	Antioch Lake	0.1448	75.89
134	Slocum Lake	0.1496	76.36
135	Drummond Lake	0.1510	76.50
136	Pond-a-Rudy	0.1514	76.54
137	Lake Matthews	0.1516	76.56
138	Buffalo Creek Reservoir	0.1550	76.88

Table 3. Continued

RANK	LAKE NAME	TP AVE	TSIp
139	Pistakee Lake (Site 1)	0.1592	77.26
140	Grassy Lake	0.1610	77.42
141	Salem Lake	0.1650	77.78
142	Half Day Pit	0.1690	78.12
143	Lake Eleanor Site II, Outflow	0.1812	79.13
144	Lake Farmington	0.1848	79.41
145	Lake Louise	0.1850	79.43
146	ADID 127	0.1886	79.71
147	Dog Bone Lake	0.1990	80.48
148	Redwing Marsh	0.2072	81.06
149	Stockholm Lake	0.2082	81.13
150	Bishop Lake	0.2156	81.63
151	Hidden Lake	0.2236	82.16
152	Fischer Lake	0.2278	82.43
153	Lake Napa Suwe (Outlet)	0.2304	82.59
154	Patski Pond (outlet)	0.2512	83.84
155	Oak Hills Lake	0.2792	85.36
156	Loch Lomond	0.2954	86.18
157	McDonald Lake 2	0.3254	87.57
158	Fairfield Marsh	0.3264	87.61
159	ADID 182	0.3280	87.69
160	Slough Lake	0.4134	91.02
161	Flint Lake Outlet	0.4996	93.75
162	Rasmussen Lake	0.5025	93.84
163	Albert Lake, Site II, outflow	1.1894	106.26

Table 3. Epilimnetic averages for select water quality parameters from previous studies of Bangs Lake.

DATE	TKN	TP	TSS	SECCHI	COND
2008	0.849	0.022	1.8	14.12	0.6202
2007	0.849	0.022	1.8	14.12	0.6202
2006	0.89	0.022	2.3	12.76	0.6199
2005	0.827	0.023	3.4	13.76	0.6064
2002	0.964	0.027	3.4	8.05	0.5538
1997	0.87	0.026	2.6	8.08	0.5228
1990	0.03	0.029	2.6	7.69	NA

Glossary

TKN = Total Kjeldahl nitrogen, mg/L
TP = Total phosphorus, mg/L
TSS = Total suspended solids, mg/L
SECCHI = Secchi disk depth, ft.
COND = Conductivity, milliSiemens/cm

SUMMARY OF AQUATIC MACROPHYTES

Plant sampling was conducted once on Bangs Lake in 2008, in July. There were 18 species of plants present (Table 4). The overall aquatic plant community has shifted slightly since 2007, Spatterdock and White Water Crowfoot was not noted during our sampling efforts while Bladderwort, Giant Duckweed, and Slender Naiad were added to the community. The three most abundant species were Eurasian Watermilfoil (EWM; 59% of sites), Watermeal (32.6% of sites), and Water Stargrass (32.6 % of the sites) (Table 5). Small Pondweed and Northern Milfoil were present in 2006, but were not found in 2007 or 2008.

EWM and Curlyleaf Pondweed are invasive, exotic species, and were found in the lake. (Figure 5) Aquatic plant harvesting has been carried out for removal of both species since the 1990's. Since 2005, the Village of Wauconda has provided LMU with weekly maps of the areas harvested. Harvesting began in early-May and ended by early-September and was concentrated in areas where EWM and Curlyleaf Pondweed were the most dense, (Figure 4) which tended to be the deeper areas of the lake. Many of the native pondweeds were found in greater densities in the shallow littoral zones (near shore). The harvesting technique appears to be an acceptable form of plant management at this time. Herbicide treatments have been done by private landowners in the past, however at this time the LMU does not recommend herbicides to be a long-term management strategy. Extensive herbicide treatments generally cause an overall decline in water quality, clarity, and species diversity. Diversity is also important for fish habitat. Bangs Lake harbors three Illinois endangered and threatened fish species (Blacknose Shiner, Iowa Darter, and Blackchin Shiner) which should be taken into consideration when planning plant management techniques. In addition, two threatened and endangered plant species have been historically found in Bangs Lake (White-stemmed Pondweed and Grass-leaved Pondweed).

Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a lake. When the light level in the water column falls below 1% of the surface light level, plants can no longer grow. The 1% light level in Bangs Lake ranged from 24 feet in October to 18 feet in September. In July plants were found down to 25 feet and in July the 1% light level was at 20 feet. These plant depths correlate with the 1% light level depths.

Floristic quality index (FQI) is an assessment tool designed to evaluate the closeness the flora of an area is to that of undisturbed conditions. Each aquatic plant in a lake is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). Non-native species were counted in the FQI calculations for Lake County lakes. In 2008, Bangs Lake had an FQI of 25.7 and ranked #10 of 152 lakes in the county (Table 6). The median FQI of lakes that we have studied from 2000-2008 is 12.5. Bangs Lake had a FQI of 24.5 in 2007, slightly lower than 2007, most likely due to annual variation in plant abundance.

Table 4: Aquatic plant species found in Bangs Lake, 2008.

Coontail	<i>Ceratophyllum demersum</i>
Chara (Macro algae)	<i>Chara</i> spp.
American Elodea	<i>Elodea canadensis</i>
Water Stargrass	<i>Heteranthera dubia</i>
Duckweed	<i>Lemna</i> spp.
Eurasian Watermilfoil [^]	<i>Myriophyllum spicatum</i>
Southern Naiad	<i>Najas guadalupensis</i>
Spatterdock	<i>Nuphar variegata</i>
White Water Lily	<i>Nymphaea tuberosa</i>
Largeleaf Pondweed	<i>Potamogeton amplifolius</i>
Curlyleaf Pondweed [^]	<i>Potamogeton crispus</i>
Illinois Pondweed	<i>Potamogeton illinoensis</i>
Sago Pondweed	<i>Potamogeton pectinatus</i>
Flatstem Pondweed	<i>Potamogeton zosteriformis</i>
White Water Crowfoot	<i>Ranunculus longirostris</i>
Eel Grass	<i>Vallisneria americana</i>
Watermeal	<i>Wolffia columbiana</i>

* **Endangered in Illinois**

[^] **Exotic plant**

Table 5a. Aquatic plant species found at the 261 sampling sites on Bangs Lake in May, 2008. The maximum depth plants were found was 25.0 feet.

Plant Density	Bladderwort	Chara	Coontail	Curlyleaf Pondweed	Duckweed	Elodea	Eurasian Watermilfoil	Flatstem Pondweed
Present	1	33	32	9	28	14	86	50
Common	1	11	22	3	9	1	25	15
Abundant	1	7	11	0	1	1	16	7
Dominant	0	11	18	0	0	1	26	0
% Plant Occurrence	1.1	23.8	31.8	4.6	14.6	6.5	58.6	27.6

Plant Density	Illinois Pondweed	Largeleaf Pondweed	Sago Pondweed	Slender Naiad	Southern Naiad	Vallisneria	Watermeal	Water Stargrass
Present	21	18	17	2	5	33	36	36
Common	19	3	14	1	0	15	18	18
Abundant	8	2	2	0	0	12	10	10
Dominant	1	1	0	0	0	3	21	21
% Plant Occurrence	18.8	9.2	12.6	1.1	1.9	24.1	32.6	32.6

Table 5b. Distribution of rake density across all sampling sites.

Rake Density (coverage)	# of Sites	% of Sites
No Plants	49	18.8
>0-10%	51	19.5
10-40%	34	13.0
40-60%	26	10.0
60-90%	16	6.1
>90%	85	32.6
Total Sites with Plants	212	81.2
Total # of Sites	261	100.0

Figure 4. Aquatic plant sampling grid illustrating plant density on Bangs Lake, July 2008.

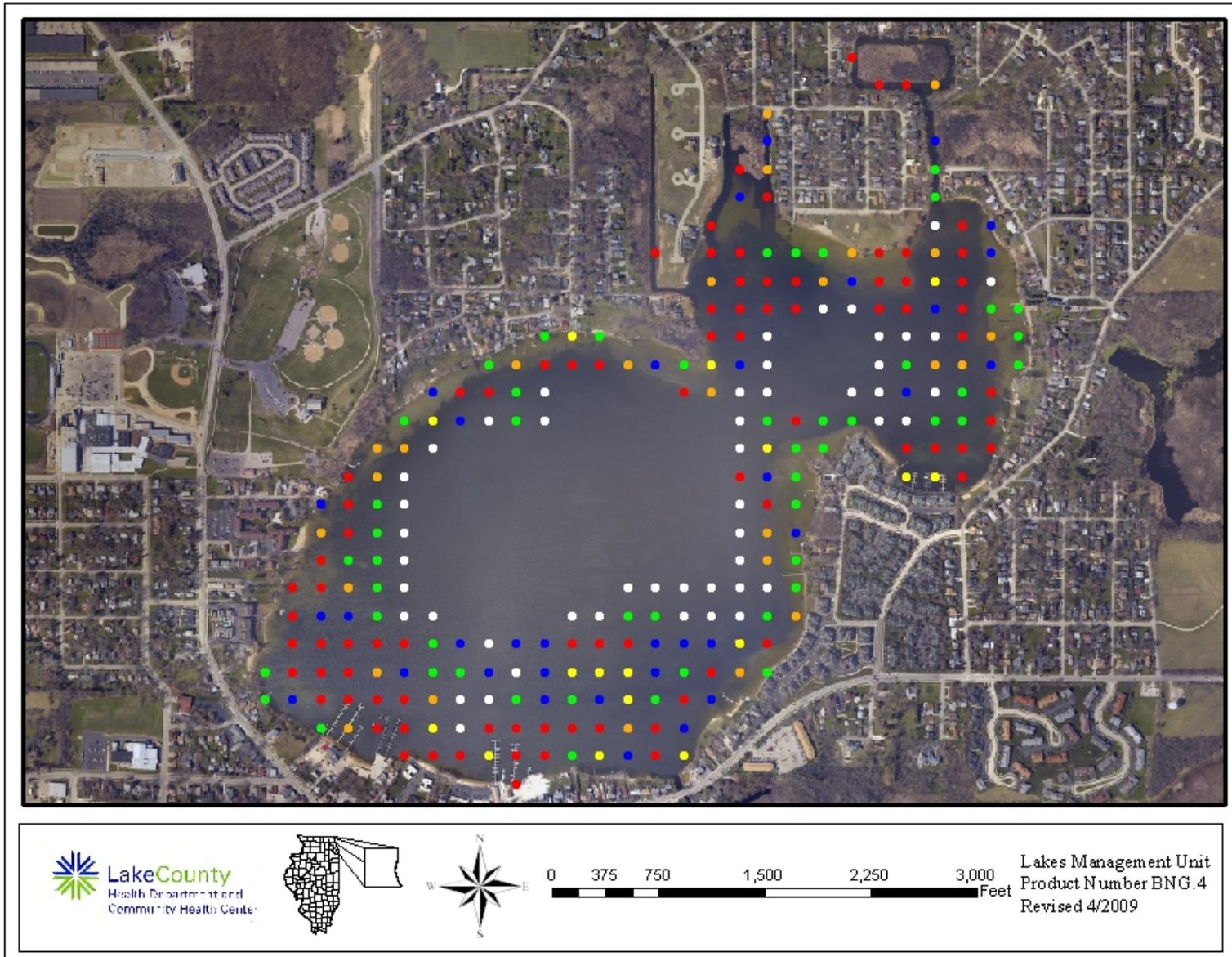


Figure 5. Aquatic plant sampling grid illustrating Eurasian Water Milfoil density on Bangs Lake, July 2008.

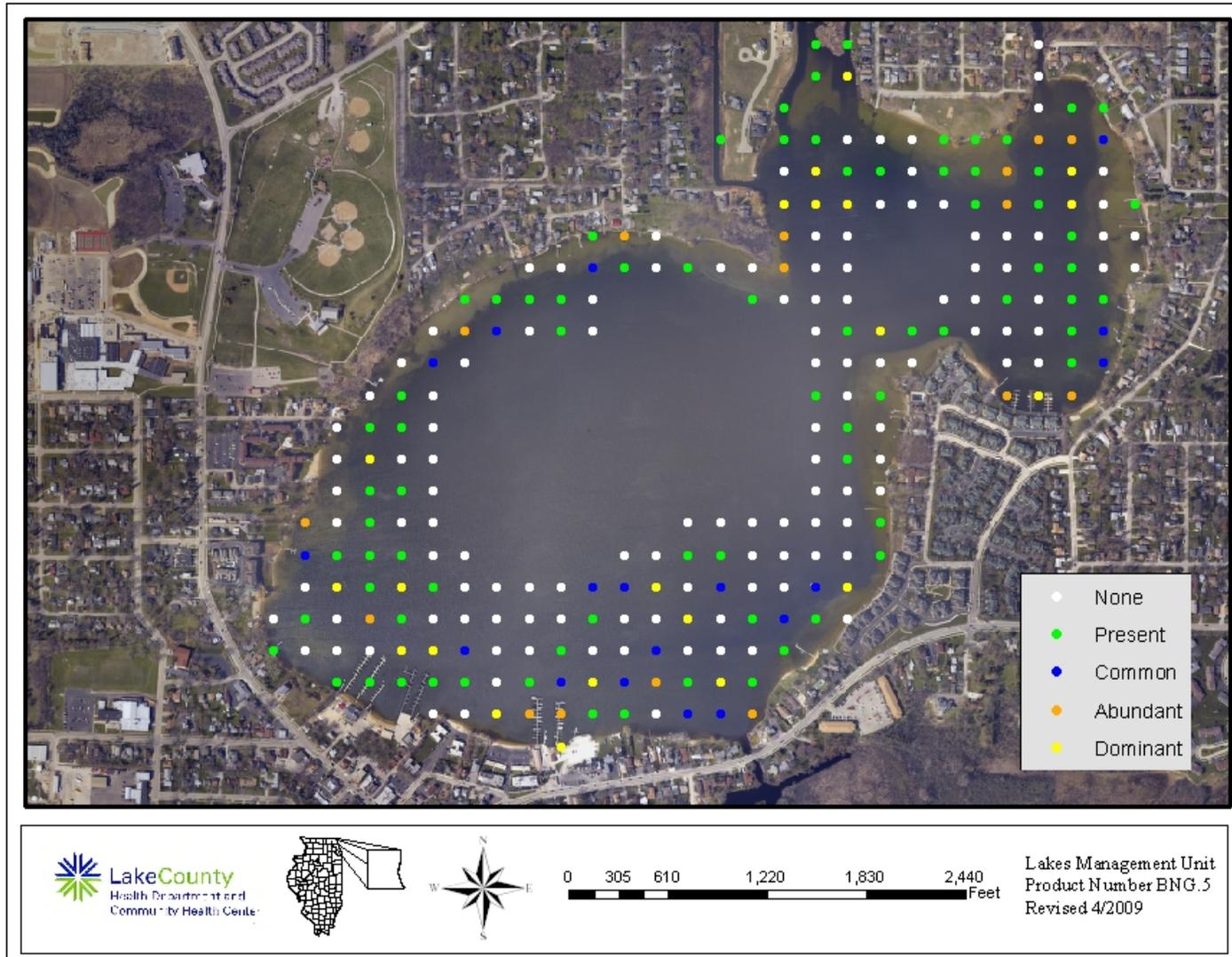


Table 6. Floristic quality index (FQI) of lakes in Lake County, calculated with exotic species (w/Adventives) and with native species only (native).

RANK	LAKE NAME	FQI (w/A)	FQI (native)
1	Cedar Lake	36.3	38.4
2	East Loon Lake	30.6	32.7
3	Cranberry Lake	30.1	31.6
4	Deep Lake	29.7	31.2
5	Little Silver	29.6	31.6
6	Round Lake Marsh North	29.1	29.9
7	Deer Lake	28.2	29.7
8	Sullivan Lake	28.2	29.7
9	Schreiber Lake	26.8	27.6
10	Bangs Lake	25.7	27.4
11	West Loon Lake	25.7	27.3
12	Cross Lake	25.2	27.8
13	Independence Grove	24.6	27.5
14	Sterling Lake	24.5	26.9
15	Lake Zurich	24.3	27.1
16	Sun Lake	24.3	26.1
17	Lake of the Hollow	23.8	26.2
18	Lakewood Marsh	23.8	24.7
19	Round Lake	23.5	25.9
20	Honey Lake	23.3	25.1
21	Fourth Lake	23.0	24.8
22	Druce Lake	22.8	25.2
23	Countryside Glen Lake	21.9	22.8
24	Butler Lake	21.4	23.1
25	Duck Lake	21.1	22.9
26	Timber Lake (North)	20.8	22.8
27	Broberg Marsh	20.5	21.4
28	Davis Lake	20.5	21.4
29	ADID 203	20.5	20.5
30	McGreal Lake	20.2	22.1
31	Lake Kathryn	19.6	20.7
32	Fish Lake	19.3	21.2
33	Owens Lake	19.3	20.2
34	Redhead Lake	19.3	21.2
35	Turner Lake	18.6	21.2
36	Wooster Lake	18.5	20.2
37	Salem Lake	18.5	20.2
38	Lake Miltmore	18.4	20.3
39	Hendrick Lake	17.7	17.7
40	Summerhill Estates Lake	17.1	18.0
41	Seven Acre Lake	17.0	15.5
42	Gray's Lake	16.9	19.8
43	Lake Barrington	16.7	17.7
44	Bresen Lake	16.6	17.8

Table 6. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
45	Diamond Lake	16.3	17.4
46	Lake Napa Suwe	16.3	17.4
47	Windward Lake	16.3	17.6
48	Dog Bone Lake	15.7	15.7
49	Redwing Slough	15.6	16.6
50	Osprey Lake	15.5	17.3
51	Lake Fairview	15.2	16.3
52	Heron Pond	15.1	15.1
53	Lake Tranquility (S1)	15.0	17.0
54	North Churchill Lake	15.0	15.0
55	Dog Training Pond	14.7	15.9
56	Island Lake	14.7	16.6
57	Highland Lake	14.5	16.7
58	Grand Avenue Marsh	14.3	16.3
59	Taylor Lake	14.3	16.3
60	Dugdale Lake	14.0	15.1
61	Eagle Lake (S1)	14.0	15.1
62	Longview Meadow Lake	13.9	13.9
63	Ames Pit	13.4	15.5
64	Bishop Lake	13.4	15.0
65	Hook Lake	13.4	15.5
66	Long Lake	13.1	15.1
67	Buffalo Creek Reservoir	13.1	14.3
68	Mary Lee Lake	13.1	15.1
69	McDonald Lake 2	13.1	14.3
70	Old School Lake	13.1	15.1
71	Dunn's Lake	12.7	13.9
72	Old Oak Lake	12.7	14.7
73	Timber Lake (South)	12.7	14.7
74	White Lake	12.7	14.7
75	Hastings Lake	12.5	14.8
76	Sand Lake	12.5	14.8
77	Stone Quarry Lake	12.5	12.5
78	Lake Carina	12.1	14.3
79	Lake Leo	12.1	14.3
80	Lambs Farm Lake	12.1	14.3
81	Pond-A-Rudy	12.1	12.1
82	Stockholm Lake	12.1	13.5
83	Grassy Lake	12	12
84	Lake Matthews	12.0	12.0
85	Flint Lake	11.8	13.0
86	Harvey Lake	11.8	13.0
87	Rivershire Pond 2	11.5	13.3
88	Antioch Lake	11.3	13.4
89	Lake Charles	11.3	13.4
90	Lake Linden	11.3	11.3

Table 6. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
91	Lake Naomi	11.2	12.5
92	Pulaski Pond	11.2	12.5
93	Lake Minear	11.0	13.9
94	Redwing Marsh	11.0	11.0
95	Tower Lake	11.0	11.0
96	West Meadow Lake	11.0	11.0
97	Nielsen Pond	10.7	12.0
98	Lake Holloway	10.6	10.6
99	Third Lake	10.2	12.5
100	Crooked Lake	10.2	12.5
101	College Trail Lake	10.0	10.0
102	Lake Lakeland Estates	10.0	11.5
103	Valley Lake	9.9	9.9
104	Werhane Lake	9.8	12.0
105	Big Bear Lake	9.5	11.0
106	Little Bear Lake	9.5	11.0
107	Loch Lomond	9.4	12.1
108	Columbus Park Lake	9.2	9.2
109	Sylvan Lake	9.2	9.2
110	Lake Louise	9	10.4
111	Fischer Lake	9.0	11.0
112	Grandwood Park Lake	9.0	11.0
113	Lake Fairfield	9.0	10.4
114	McDonald Lake 1	8.9	10.0
115	Countryside Lake	8.7	10.6
116	East Meadow Lake	8.5	8.5
117	Lake Christa	8.5	9.8
118	Lake Farmington	8.5	9.8
119	Lucy Lake	8.5	9.8
120	South Churchill Lake	8.5	8.5
121	Bittersweet Golf Course #13	8.1	8.1
122	Woodland Lake	8.1	9.9
123	Albert Lake	7.5	8.7
124	Banana Pond	7.5	9.2
125	Fairfield Marsh	7.5	8.7
126	Lake Eleanor	7.5	8.7
127	Patski Pond	7.1	7.1
128	Rasmussen Lake	7.1	7.1
129	Slough Lake	7.1	7.1
130	Lucky Lake	7.0	7.0
131	Lake Forest Pond	6.9	8.5
132	Leisure Lake	6.4	9.0
133	Peterson Pond	6.0	8.5
134	Gages Lake	5.8	10.0
135	Slocum Lake	5.8	7.1
136	Deer Lake Meadow Lake	5.2	6.4

Table 6. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
137	ADID 127	5.0	5.0
138	Drummond Lake	5.0	7.1
139	IMC Lake	5.0	7.1
140	Liberty Lake	5.0	5.0
141	Oak Hills Lake	5.0	5.0
142	Forest Lake	3.5	5.0
143	Sand Pond (IDNR)	3.5	5.0
144	Half Day Pit	2.9	5.0
145	Lochanora Lake	2.5	5.0
146	Echo Lake	0.0	0.0
147	Hidden Lake	0.0	0.0
148	North Tower Lake	0.0	0.0
149	Potomac Lake	0.0	0.0
150	St. Mary's Lake	0.0	0.0
151	Waterford Lake	0.0	0.0
152	Willow Lake	0.0	0.0
	<i>Mean</i>	13.6	14.9
	<i>Median</i>	12.5	14.3

**APPENDIX A. METHODS FOR FIELD DATA COLLECTION AND
LABORATORY ANALYSES**

Water Sampling and Laboratory Analyses

Two water samples were collected once a month from May through September. Sample locations were at the deepest point in the lake (see sample site map), three feet below the surface, and 3 feet above the bottom. Samples were collected with a horizontal Van Dorn water sampler. Approximately three liters of water were collected for each sample for all lab analyses. After collection, all samples were placed in a cooler with ice until delivered to the Lake County Health Department lab, where they were refrigerated. Analytical methods for the parameters are listed in Table A1. Except nitrate nitrogen, all methods are from the Eighteenth Edition of Standard Methods, (eds. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1992). Methodology for nitrate nitrogen was taken from the 14th edition of Standard Methods. Dissolved oxygen, temperature, conductivity and pH were measured at the deep hole with a Hydrolab DataSonde® 4a. Photosynthetic Active Radiation (PAR) was recorded using a LI-COR® 192 Spherical Sensor attached to the Hydrolab DataSonde® 4a. Readings were taken at the surface and then every two feet until reaching the bottom.

Plant Sampling

In order to randomly sample each lake, mapping software (ArcMap 9.3) overlaid a grid pattern onto an aerial photo of Lake County and placed points 60 or 30 meters apart, depending on lake size. Plants were sampled using a garden rake fitted with hardware cloth. The hardware cloth surrounded the rake tines and is tapered two feet up the handle. A rope was tied to the end of the handle for retrieval. At designated sampling sites, the rake was tossed into the water, and using the attached rope, was dragged across the bottom, toward the boat. After pulling the rake into the boat, plant coverage was assessed for overall abundance. Then plants were individually identified and placed in categories based on coverage. Plants that were not found on the rake but were seen in the immediate vicinity of the boat at the time of sampling were also recorded. Plants difficult to identify in the field were placed in plastic bags and identified with plant keys after returning to the office. The depth of each sampling location was measured either by a hand-held depth meter, or by pushing the rake straight down and measuring the depth along the rope or rake handle. One-foot increments were marked along the rope and rake handle to aid in depth estimation.

Wildlife Assessment

Species of wildlife were noted during visits to each lake. When possible, wildlife was identified to species by sight or sound. However, due to time constraints, collection of quantitative information was not possible. Thus, all data should be considered anecdotal. Some of the species on the list may have only been seen once, or were spotted during their migration through the area.

Table A1. Analytical methods used for water quality parameters.

<i>Parameter</i>	<i>Method</i>
Temperature	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Dissolved oxygen	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Nitrate and Nitrite nitrogen	USEPA 353.2 rev. 2.0 EPA-600/R-93/100 Detection Limit = 0.05 mg/L
Ammonia nitrogen	SM 18 th ed. Electrode method, #4500 NH ₃ -F Detection Limit = 0.1 mg/L
Total Kjeldahl nitrogen	SM 18 th ed, 4500-N _{org} C Semi-Micro Kjeldahl, plus 4500 NH ₃ -F Detection Limit = 0.5 mg/L
pH	Hydrolab DataSonde® 4a, or YSI 6600 Sonde® Electrometric method
Total solids	SM 18 th ed, Method #2540B
Total suspended solids	SM 18 th ed, Method #2540D Detection Limit = 0.5 mg/L
Chloride	SM 18 th ed, Method #4500C1-D
Total volatile solids	SM 18 th ed, Method #2540E, from total solids
Alkalinity	SM 18 th ed, Method #2320B, potentiometric titration curve method
Conductivity	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Total phosphorus	SM 18 th ed, Methods #4500-P B 5 and #4500-P E Detection Limit = 0.01 mg/L
Soluble reactive phosphorus	SM 18 th ed, Methods #4500-P B 1 and #4500-P E Detection Limit = 0.005 mg/L
Clarity	Secchi disk
Color	Illinois EPA Volunteer Lake Monitoring Color Chart
Photosynthetic Active Radiation (PAR)	Hydrolab DataSonde® 4a or YSI 6600 Sonde®, LI-COR® 192 Spherical Sensor

APPENDIX B. MULTI-PARAMETER DATA FOR BANGS LAKE IN 2008.

Bangs Lake 2008 Multiparameter data

Text												
Date	Time	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light Meter	% Light Transmission	Extinction Coefficient
MMDDYY	HHMMSS	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Average	0.73
41608	93856	0.25	0.2	8.41	11.10	97.8	0.6293	8.19	4624	Surface	100%	
41608	94013	1	1.23	8.4	11.11	97.7	0.6298	8.25	4404	Surface	100%	
41608	94058	2	1.85	8.41	11.10	97.6	0.6298	8.28	2282	0.1	52%	6.57
41608	94150	3	3.24	8.41	11.08	97.6	0.6299	8.31	1612	1.49	37%	0.23
41608	94257	4	3.83	8.4	11.09	97.7	0.6296	8.34	1065	2.08	24%	0.20
41608	94352	6	6.19	8.41	11.07	97.5	0.6298	8.4	584	4.44	13%	0.14
41608	94439	8	7.62	8.41	11.05	97.3	0.6296	8.44	469	5.87	11%	0.04
41608	94531	10	10.22	8.39	11.05	97.3	0.6297	8.49	326	8.47	7%	0.04
41608	94619	12	11.89	8.38	11.04	97.2	0.63	8.52	282	10.14	6%	0.01
41608	94707	14	14.08	8.41	11.04	97.1	0.6298	8.57	176	12.33	4%	0.04
41608	94823	16	15.94	8.4	11.00	96.9	0.6295	8.6	128	14.19	3%	0.02
41608	94907	18	17.87	8.42	11.00	96.8	0.6299	8.66	82	16.12	2%	0.03
41608	94951	20	20.03	8.4	10.99	96.8	0.6296	8.67	53	18.28	1.2%	0.02
41608	95041	22	22.17	8.4	11.00	96.8	0.6299	8.7	32	20.42	0.7%	0.02
41608	95122	24	23.63	8.38	11.01	96.9	0.6297	8.72	22	21.88	0.5%	0.02
41608	95216	26	25.89	8.37	11.00	96.7	0.6299	8.76	10	24.14	0.2%	0.03

Text												
Date	Time	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light Meter	% Light Transmission	Extinction Coefficient
MMDDYY	HHMMSS	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Average	0.29
52108	94511	0.25	0.37	15.72	10.94	114.7	0.6336	8.63	4395	Surface	100%	
52108	94618	1	0.96	15.73	10.94	114.7	0.6336	8.66	4230	Surface	100%	
52108	94718	2	2.05	15.74	10.94	114.7	0.6336	8.68	1574	0.3	37%	3.30
52108	94827	3	3.08	15.71	10.95	114.8	0.6334	8.68	286	1.33	7%	1.28
52108	95006	4	3.98	15.68	10.96	114.8	0.6336	8.68	940	2.23	22%	-0.53
52108	95111	6	6.02	15.71	10.93	114.6	0.6336	8.73	808	4.27	19%	0.04
52108	95155	8	7.98	15.67	10.95	114.6	0.6336	8.75	708	6.23	17%	0.02
52108	95247	10	10.03	15.67	10.92	114.4	0.6338	8.76	377	8.28	9%	0.08

52108	95339	12	11.99	15.65	10.93	114.4	0.6334	8.77	276	10.24	7%	0.03
52108	95437	14	14.02	15.61	10.9	114	0.6334	8.76	164	12.27	4%	0.04
52108	95527	16	15.98	15.46	10.6	110.5	0.633	8.74	116	14.23	3%	0.02
52108	95638	18	18.03	15.43	10.49	109.3	0.6331	8.7	86	16.28	2%	0.02
52108	95718	20	20.01	15.38	10.35	107.7	0.6336	8.73	15	18.26	0%	0.10
52108	95810	22	21.99	15.31	9.93	103.2	0.6348	8.65	57	20.24	1%	-0.07
52108	95907	24	24	15.24	9.43	97.8	0.6352	8.6	44	22.25	1%	0.01
52108	95955	26	25.99	15.12	9.58	99.1	0.6345	8.65	35	24.24	0.8%	0.01
52108	100126	28	28.05	15.01	9.72	100.3	0.6342	8.62	29	26.3	0.7%	0.01

Date	Time	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light	% Light	Extinction
MMDDYY	HHMMSS	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	Meter	Transmission	Coefficient
											Average	0.18
61808	93515	0.25	0.24	22.78	8.32	99.7	0.6149	8.51	4317	Surface	100%	
61808	93729	1	1.08	23.15	8.21	99.2	0.6115	8.5	4693	Surface	100%	
61808	93848	2	2.13	23.17	8.21	99.1	0.6117	8.54	2035	0.38	43%	2.20
61808	94009	3	2.97	23.13	8.22	99.2	0.6109	8.55	1725	1.22	37%	0.14
61808	94112	4	4	22.97	8.26	99.3	0.6117	8.58	1484	2.25	32%	0.07
61808	94230	6	6.08	22.66	8.19	97.9	0.6109	8.59	996	4.33	21%	0.09
61808	94403	8	7.91	22.58	8.06	96.3	0.6116	8.57	787	6.16	17%	0.04
61808	94512	10	10.01	22.54	7.89	94.1	0.6124	8.57	469	8.26	10%	0.06
61808	94610	12	12.03	22.49	7.86	93.8	0.6121	8.58	320	10.28	7%	0.04
61808	94708	14	13.96	22.43	7.6	90.6	0.6127	8.54	224	12.21	5%	0.03
61808	94808	16	16.03	22.3	7.58	90	0.6116	8.57	145	14.28	3%	0.03
61808	94912	18	18	20.79	3.73	43	0.6274	8	109	16.25	2.3%	0.02
61808	95025	20	19.63	18.81	1.72	19.1	0.641	7.79	79	17.88	1.7%	0.02
61808	95121	22	21.99	17.66	0.85	9.2	0.6443	7.75	56	20.24	1.2%	0.02
61808	95407	24	23.99	16.97	0.33	3.5	0.647	7.65	38	22.24	0.8%	0.02
61808	95528	26	26.04	16.85	0.24	2.6	0.6476	7.66	25	24.29	0.5%	0.02
61808	95625	28	28.02	16.56	0.17	1.8	0.6505	7.69	14	26.27	0.3%	0.02
61808	95803	30	30.03	16.47	0.16	1.7	0.6523	7.69	9	28.28	0.2%	0.02

Date	Time	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light	% Light	Extinction
										Meter		

MMDDYY	HHMMSS	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Transmission Average	Coefficient 0.50
71608	94400	0.25	0.38	26.44	9.17	117.3	0.6101	8.8	3612	Surface	100%	
71608	94509	1	0.97	26.39	9.2	117.5	0.611	8.8	3525	Surface	100%	
71608	94558	2	2.01	26.41	9.21	117.8	0.6099	8.84	506	0.26	14%	7.47
71608	94651	3	3	25.85	9.16	115.9	0.6095	8.81	1134	1.25	32%	-0.65
71608	94733	4	4.02	25.66	8.67	109.3	0.6103	8.79	599	2.27	17%	0.28
71608	94904	6	6	25.48	8.3	104.3	0.6115	8.69	504	4.25	14%	0.04
71608	95017	8	7.98	25.32	8.48	106.3	0.6118	8.71	349	6.23	10%	0.06
71608	95059	10	9.99	25.2	8.4	105	0.6125	8.71	269	8.24	8%	0.03
71608	95145	12	11.99	25.09	8.25	103	0.6122	8.7	202	10.24	6%	0.03
71608	95240	14	13.97	24.76	7.43	92.1	0.6129	8.58	138	12.22	3.9%	0.03
71608	95336	16	16.11	24.38	7.1	87.4	0.6127	8.52	79	14.36	2.2%	0.04
71608	95410	18	17.97	24.1	6.77	82.9	0.6134	8.45	59	16.22	1.7%	0.02
71608	95505	20	19.82	23.33	4.35	52.5	0.6193	8.08	46	18.07	1.3%	0.01
71608	95559	22	21.99	22.49	1.36	16.1	0.627	7.75	26	20.24	0.7%	0.03
71608	95717	24	23.96	19.76	0.23	2.6	0.6485	7.7	19	22.21	0.5%	0.01
71608	95818	26	26.06	17.79	0.19	2.1	0.6623	7.77	9	24.31	0.3%	0.03
71608	95909	28	28.07	17.13	0.18	1.9	0.6667	7.81	6	26.32	0.2%	0.02
71608	95959	30	30.06	16.54	0.17	1.8	0.6723	7.83	4	28.31	0.1%	0.01

Text

Date MMDDYY	Time HHMMSS	Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient 0.25
82008	102140	0.25	0.47	25.61	8.45	105.9	0.6207	8.55	3795	Surface	100%	
82008	102250	1	1	25.63	8.43	105.7	0.6205	8.55	4004	Surface	100%	
82008	102342	2	2.02	25.59	8.43	105.6	0.6205	8.55	1632	0.27	41%	3.32
82008	102520	3	3.04	25.56	8.44	105.6	0.6205	8.56	1475	1.29	37%	0.08
82008	102617	4	4.01	25.51	8.43	105.4	0.6208	8.56	1167	2.26	29%	0.10
82008	102727	6	6.01	25.32	8.44	105.2	0.62	8.57	619	4.26	15%	0.15
82008	102900	8	8	25.23	8.31	103.4	0.62	8.57	355	6.25	9%	0.09
82008	103012	10	9.92	25.17	8.32	103.4	0.62	8.57	199	8.17	5%	0.07
82008	103107	12	12.03	25.09	7.85	97.4	0.6208	8.52	204	10.28	5%	0.00
82008	103230	14	14	25.05	7.47	92.7	0.6203	8.46	125	12.25	3.1%	0.04

82008	103426	16	16.03	24.96	6.78	83.9	0.6222	8.39	80	14.28	2.0%	0.03
82008	103518	18	17.99	24.79	6.08	75	0.6233	8.28	59	16.24	1.5%	0.02
82008	103627	20	19.92	24.29	3.88	47.5	0.624	8.02	42	18.17	1.0%	0.02
82008	103720	22	21.95	23.7	0.7	8.4	0.6276	7.82	30	20.2	0.7%	0.02
82008	103839	24	24.04	22.64	0.24	2.8	0.6389	7.7	15	22.29	0.4%	0.03
82008	103930	26	26.01	21.19	0.18	2.1	0.6556	7.64	10	24.26	0.2%	0.02
82008	104026	28	28.06	18.86	0.17	1.9	0.6888	7.5	5	26.31	0.1%	0.03
82008	104117	30	29.98	18.1	0.17	1.8	0.702	7.53	3	28.23	0.1%	0.02

BNG		Text									Depth of Light	% Light	Extinction
Date	Time	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Meter	Transmission	Coefficient	
MMDDYY	HHMMSS	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Average	0.35	
91708	75834	0.25	0.55	20.04	7.94	89.8	0.5968	8.36	3656	Surface	100%		
91708	75937	1	1.07	20.04	7.89	89.2	0.5967	8.2	3775	Surface	100%		
91708	80058	2	2	20.04	7.89	89.3	0.5966	8.17	1131	0.25	30%	4.82	
91708	80200	3	2.96	20.04	7.88	89.1	0.5966	8.17	779	1.21	21%	0.31	
91708	80356	4	3.93	20.04	7.87	89	0.5966	8.18	674	2.18	18%	0.07	
91708	80446	6	5.96	20.03	7.87	89	0.5963	8.17	610	4.21	16%	0.02	
91708	80619	8	7.9	20.02	7.86	88.8	0.5959	8.18	210	6.15	6%	0.17	
91708	80834	10	9.86	20.02	7.86	88.9	0.5958	8.19	192	8.11	5%	0.01	
91708	80942	12	12.09	20.02	7.86	88.8	0.5958	8.18	110	10.34	3%	0.05	
91708	81110	14	14.03	20.02	7.86	88.8	0.5955	8.19	75	12.28	2%	0.03	
91708	81235	16	16.01	20.01	7.86	88.8	0.5947	8.19	49	14.26	1.3%	0.03	
91708	81332	18	17.87	20	7.84	88.6	0.5944	8.18	35	16.12	0.9%	0.02	
91708	81428	20	19.93	19.97	7.7	86.9	0.5947	8.16	25	18.18	0.7%	0.02	
91708	81622	22	22.05	19.9	7.34	82.8	0.5954	8.12	18	20.3	0.5%	0.02	
91708	81753	24	23.98	19.81	6.97	78.5	0.5964	8.07	14	22.23	0.4%	0.01	
91708	81854	26	25.88	19.66	6.57	73.7	0.5895	8	11	24.13	0.3%	0.01	
91708	82007	28	28.03	19.32	5.85	65.2	0.5661	7.86	8	26.28	0.2%	0.01	
91708	82202	30	30.04	19.18	5.47	60.8	0.5616	7.74	6	28.29	0.2%	0.01	

		Text									Depth of Light	% Light	Extinction
Date	Time	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Meter	Transmission	Coefficient	
MMDDYY	HHMMSS	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet			

110508	101409	0.25	0.56	11.52	10.49	99.2	0.5956	8.16	4835	Surface	Average	0.35
110508	101511	1	1.13	11.52	10.42	98.6	0.5957	8.19	4631	Surface	100%	
110508	101603	2	2.03	11.52	10.47	99.1	0.5958	8.19	1379	0.28	30%	4.33
110508	101703	3	3.07	11.51	10.47	99.0	0.5958	8.18	1047	1.32	23%	0.21
110508	101745	4	4.06	11.52	10.45	98.8	0.5956	8.16	867	2.31	19%	0.08
110508	101846	6	5.88	11.48	10.45	98.7	0.5957	8.16	498	4.13	11%	0.13
110508	101933	8	7.96	11.52	10.43	98.7	0.5958	8.16	437	6.21	9%	0.02
110508	102053	10	10.15	11.5	10.43	98.6	0.5958	8.15	308	8.4	7%	0.04
110508	102121	12	11.99	11.44	10.41	98.2	0.5955	8.14	225	10.24	5%	0.03
110508	102252	14	14.18	11.37	10.41	98.1	0.5961	8.14	173	12.43	4%	0.02
110508	102350	16	15.95	11.32	10.42	98.1	0.5959	8.14	126	14.2	3%	0.02
110508	102457	18	17.89	11.32	10.39	97.9	0.5951	8.13	96	16.14	2%	0.02
110508	102604	20	19.88	11.32	10.38	97.7	0.5952	8.13	71	18.13	1.5%	0.02
110508	102648	22	22.04	11.29	10.36	97.5	0.5951	8.13	53	20.29	1.1%	0.01
110508	102800	24	24.06	11.28	10.36	97.5	0.5951	8.12	44	22.31	1.0%	0.01
110508	103021	26	25.58	11.29	9.96	93.7	0.5881	8.08	37	23.83	0.8%	0.01

**APPENDIX C. INTERPRETING YOUR LAKE'S WATER QUALITY
DATA**

Lakes possess a unique set of physical and chemical characteristics that will change over time. These in-lake water quality characteristics, or parameters, are used to describe and measure the quality of lakes, and they relate to one another in very distinct ways. As a result, it is virtually impossible to change any one component in or around a lake without affecting several other components, and it is important to understand how these components are linked.

The following pages will discuss the different water quality parameters measured by Lake County Health Department staff, how these parameters relate to each other, and why the measurement of each parameter is important. The median values (the middle number of the data set, where half of the numbers have greater values, and half have lesser values) of data collected from Lake County lakes from 2000-2008 will be used in the following discussion.

Temperature and Dissolved Oxygen:

Water temperature fluctuations will occur in response to changes in air temperatures, and can have dramatic impacts on several parameters in the lake. In the spring and fall, lakes tend to have uniform, well-mixed conditions throughout the water column (surface to the lake bottom). However, during the summer, deeper lakes will separate into distinct water layers. As surface water temperatures increase with increasing air temperatures, a large density difference will form between the heated surface water and colder bottom water. Once this difference is large enough, these two water layers will separate and generally will not mix again until the fall. At this time the lake is thermally stratified. The warm upper water layer is called the *epilimnion*, while the cold bottom water layer is called the *hypolimnion*. In some shallow lakes, stratification and destratification can occur several times during the summer. If this occurs the lake is described as polymictic. Thermal stratification also occurs to a lesser extent during the winter, when warmer bottom water becomes separated from ice-forming water at the surface until mixing occurs during spring ice-out.

Monthly temperature profiles were established on each lake by measuring water temperature every foot (lakes \leq 15 feet deep) or every two feet (lakes $>$ 15 feet deep) from the lake surface to the lake bottom. These profiles are important in understanding the distribution of chemical/biological characteristics and because increasing water temperature and the establishment of thermal stratification have a direct impact on dissolved oxygen (DO) concentrations in the water column. If a lake is shallow and easily mixed by wind, the DO concentration is usually consistent throughout the water column. However, shallow lakes are typically dominated by either plants or algae, and increasing water temperatures during the summer speeds up the rates of photosynthesis and decomposition in surface waters. When many of the plants or algae die at the end of the growing season, their decomposition results in heavy oxygen consumption and can lead to an oxygen crash. In deeper, thermally stratified lakes, oxygen production is greatest in the top portion of the lake, where sunlight drives photosynthesis, and oxygen consumption is greatest near the bottom of a lake, where sunken organic matter accumulates and decomposes. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom. The oxygen profiles measured during the water quality study can illustrate if

this is occurring. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters. Low oxygen conditions in the upper water of a lake can also be problematic since all aquatic organisms need oxygen to live. Some oxygen may be present in the water, but at too low a concentration to sustain aquatic life. Oxygen is needed by all plants, virtually all algae and for many chemical reactions that are important in lake functioning. Most adult sport-fish such as largemouth bass and bluegill require at least 3 mg/L of DO in the water to survive. However, their offspring require at least 5 mg/L DO as they are more sensitive to DO stress. When DO concentrations drop below 3 mg/L, rough fish such as carp and green sunfish are favored and over time will become the dominant fish species.

External pollution in the form of oxygen-demanding organic matter (i.e., sewage, lawn clippings, soil from shoreline erosion, and agricultural runoff) or nutrients that stimulate the growth of excessive organic matter (i.e., algae and plants) can reduce average DO concentrations in the lake by increasing oxygen consumption. This can have a detrimental impact on the fish community, which may be squeezed into a very small volume of water as a result of high temperatures in the epilimnion and low DO levels in the hypolimnion.

Nutrients:

Phosphorus:

For most Lake County lakes, phosphorus is the nutrient that limits plant and algae growth. This means that any addition of phosphorus to a lake will typically result in algae blooms or high plant densities during the summer. The source of phosphorus to a lake can be external or internal (or both). External sources of phosphorus enter a lake through point (i.e., storm pipes and wastewater discharge) and non-point runoff (i.e., overland water flow). This runoff can pick up large amounts of phosphorus from agricultural fields, septic systems or impervious surfaces before it empties into the lake.

Internal sources of phosphorus originate within the lake and are typically linked to the lake sediment. In lakes with high oxygen levels (oxic), phosphorus can be released from the sediment through plants or sediment resuspension. Plants take up sediment-bound phosphorus through their roots, releasing it in small amounts to the water column throughout their life cycles, and in large amounts once they die and begin to decompose. Sediment resuspension can occur through biological or mechanical means. Bottom-feeding fish, such as common carp and black bullhead can release phosphorus by stirring up bottom sediment during feeding activities and can add phosphorus to a lake through their fecal matter. Sediment resuspension, and subsequent phosphorus release, can also occur via wind/wave action or through the use of artificial aerators, especially in shallow lakes. In lakes that thermally stratify, internal phosphorus release can occur from the sediment through chemical means. Once oxygen is depleted (anoxia) in the hypolimnion, chemical reactions occur in which phosphorus bound to iron complexes in the sediment becomes soluble and is released into the water column. This phosphorus is trapped in the hypolimnion and is unavailable to algae until fall turnover, and can cause algae blooms once

it moves into the sunlit surface water at that time. Accordingly, many of the lakes in Lake County are plagued by dense algae blooms and excessive, exotic plant coverage, which negatively affect DO levels, fish communities and water clarity.

Lakes with an average phosphorus concentration greater than 0.05 mg/L are considered nutrient rich. The median near surface total phosphorus (TP) concentration in Lake County lakes from 2000-2008 is 0.065 mg/L and ranged from a non-detectable minimum of <0.010 mg/L on five lakes to a maximum of 3.880 mg/L on Albert Lake. The median anoxic TP concentration in Lake County lakes from 2000-2008 was 0.181 mg/L and ranged from a minimum of 0.012 mg/L in Independence Grove Lake to a maximum of 3.880 mg/L in Taylor Lake.

The analysis of phosphorus also included soluble reactive phosphorus (SRP), a dissolved form of phosphorus that is readily available for plant and algae growth. SRP is not discussed in great detail in most of the water quality reports because SRP concentrations vary throughout the season depending on how plants and algae absorb and release it. It gives an indication of how much phosphorus is available for uptake, but, because it does not take all forms of phosphorus into account, it does not indicate how much phosphorus is truly present in the water column. TP is considered a better indicator of a lake's nutrient status because its concentrations remain more stable than soluble reactive phosphorus. However, elevated SRP levels are a strong indicator of nutrient problems in a lake.

Nitrogen:

Nitrogen is also an important nutrient for plant and algae growth. Sources of nitrogen to a lake vary widely, ranging from fertilizer and animal wastes, to human waste from sewage treatment plants or failing septic systems, to groundwater, air and rainfall. As a result, it is very difficult to control or reduce nitrogen inputs to a lake. Different forms of nitrogen are present in a lake under different oxic conditions. NH_4^+ (ammonium) is released from decomposing organic material under anoxic conditions and accumulates in the hypolimnion of thermally stratified lakes. If NH_4^+ comes into contact with oxygen, it is immediately converted to NO_2^- (nitrite) which is then oxidized to NO_3^- (nitrate). Therefore, in a thermally stratified lake, levels of NH_4^+ would only be elevated in the hypolimnion and levels of NO_3^- would only be elevated in the epilimnion. Both NH_4^+ and NO_3^- can be used as a nitrogen source by aquatic plants and algae. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen plus ammonium. Adding the concentrations of TKN and nitrate together gives an indication of the amount of total nitrogen present in the water column. If inorganic nitrogen (NO_3^- , NO_2^- , NH_4^+) concentrations exceed 0.3 mg/L in spring, sufficient nitrogen is available to support summer algae blooms. However, low nitrogen levels do not guarantee limited algae growth the way low phosphorus levels do. Nitrogen gas in the air can dissolve in lake water and blue-green algae can "fix" atmospheric nitrogen, converting it into a usable form. Since other types of algae do not have the ability to do this, nuisance blue-green algae blooms are typically associated with lakes that are nitrogen limited (i.e., have low nitrogen levels).

The ratio of TKN plus nitrate nitrogen to total phosphorus (TN:TP) can indicate whether plant/algae growth in a lake is limited by nitrogen or phosphorus. Ratios of less than 10:1

suggest a system limited by nitrogen, while lakes with ratios greater than 20:1 are limited by phosphorus. It is important to know if a lake is limited by nitrogen or phosphorus because any addition of the limiting nutrient to the lake will, likely, result in algae blooms or an increase in plant density.

Solids:

Although several forms of solids (total solids, total suspended solids, total volatile solids, total dissolved solids) were measured each month by the Lakes Management Staff, total suspended solids (TSS) and total volatile solids (TVS) have the most impact on other variables and on the lake as a whole. TSS are particles of algae or sediment suspended in the water column. High TSS concentrations can result from algae blooms, sediment resuspension, and/or the inflow of turbid water, and are typically associated with low water clarity and high phosphorus concentrations in many lakes in Lake County. Low water clarity and high phosphorus concentrations, in turn, exacerbate the high TSS problem by leading to reduced plant density (which stabilize lake sediment) and increased occurrence of algae blooms. The median TSS value in epilimnetic waters in Lake County is 8.2 mg/L, ranging from below the 0.1 mg/L detection limit to 165 mg/L in Fairfield Marsh.

TVS represents the fraction of total solids that are organic in nature, such as algae cells, tiny pieces of plant material, and/or tiny animals (zooplankton) in the water column. High TVS values indicate that a large portion of the suspended solids may be made up of algae cells. This is important in determining possible sources of phosphorus to a lake. If much of the suspended material in the water column is determined to be resuspended sediment that is releasing phosphorus, this problem would be addressed differently than if the suspended material was made up of algae cells that were releasing phosphorus. The median TVS value was 132.8 mg/L, ranging from 34.0 mg/L in Pulaski Pond to 298.0 mg/L in Fairfield Marsh.

Total dissolved solids (TDS) are the amount of dissolved substances, such as salts or minerals, remaining in water after evaporation. These dissolved solids are discussed in further detail in the *Alkalinity* and *Conductivity* sections of this document. TDS concentrations were measured in Lake County lakes prior to 2004, but was discontinued due to the strong correlation of TDS to conductivity and chloride concentrations.

Water Clarity:

Water clarity (transparency) is not a chemical property of lake water, but is often an indicator of a lake's overall water quality. It is affected by a lake's water color, which is a reflection of the amount of total suspended solids and dissolved organic chemicals. Thus, transparency is a measure of particle concentration and is measured with a Secchi disk. Generally, the lower the clarity or Secchi depth, the poorer the water quality. A decrease in Secchi depth during the summer occurs as the result of an increase in suspended solids (algae or sediment) in the water column. Aquatic plants play an important role in the level of water clarity and can, in turn, be negatively affected by low clarity levels. Plants increase clarity by competing with algae for

resources and by stabilizing sediments to prevent sediment resuspension. A lake with a healthy plant community will almost always have higher water clarity than a lake without plants. Additionally, if the plants in a lake are removed (through herbicide treatment or the stocking of grass carp), the lake will probably become dominated by algae and Secchi depth will decrease. This makes it very difficult for plants to become re-established due to the lack of available sunlight and the lake will, most likely, remain turbid. Turbidity will be accelerated if the lake is very shallow and/or common carp are present. Shallow lakes are more susceptible to sediment resuspension through wind/wave action and are more likely to experience clarity problems if plants are not present to stabilize bottom sediment.

Common Carp are prolific fish that feed on invertebrates in the sediment. Their feeding activities stir up bottom sediment and can dramatically decrease water clarity in shallow lakes. As mentioned above, lakes with low water clarity are, generally, considered to have poor water quality. This is because the causes and effects of low clarity negatively impact the plant and fish communities, as well as the levels of phosphorus in a lake. The detrimental impacts of low Secchi depth to plants has already been discussed. Fish populations will suffer as water clarity decreases due to a lack of food and decreased ability to successfully hunt for prey. Bluegills are planktivorous fish and feed on invertebrates that inhabit aquatic plants. If low clarity results in the disappearance of plants, this food source will disappear too. Largemouth Bass and Northern Pike are piscivorous fish that feed on other fish and hunt by sight. As the water clarity decreases, these fish species find it more difficult to see and ambush prey and may decline in size as a result. This could eventually lead to an imbalance in the fish community. Phosphorus release from resuspended sediment could increase as water clarity and plant density decrease. This would then result in increased algae blooms, further reducing Secchi depth and aggravating all problems just discussed. The average Secchi depth for Lake County lakes is 3.12 feet. From 2000-2008, Fairfield Marsh and Patski Pond had the lowest Secchi depths (0.33 feet) and Bangs Lake had the highest (29.23 feet). As an example of the difference in Secchi depth based on plant coverage, South Churchill Lake, which had no plant coverage and large numbers of Common Carp in 2003 had an average Secchi depth of 0.73 feet (over four times lower than the county average), while Deep Lake, which had a diverse plant community and few carp had an average 2003 Secchi depth of 12.48 feet (almost four times higher than the county average).

Another measure of clarity is the use of a light meter. The light meter measures the amount of light at the surface of the lake and the amount of light at each depth in the water column. The amount of attenuation and absorption (decreases) of light by the water column are major factors controlling temperature and potential photosynthesis. Light intensity at the lake surface varies seasonally and with cloud cover, and decreases with depth. The deeper into the water column light penetrates, the deeper potential plant growth. The maximum depth at which algae and plants can grow underwater is usually at the depth where the amount of light available is reduced to 0.5%-1% of the amount of light available at the lake surface. This is called the euphotic (sunlit) zone. A general rule of thumb in Lake County is that the 1% light level is about 1 to 3 times the Secchi disk depth.

Alkalinity, Conductivity, Chloride, pH:

Alkalinity:

Alkalinity is the measurement of the amount of acid necessary to neutralize carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions in the water, and represents the buffering capacity of a body of water. The alkalinity of lake water depends on the types of minerals in the surrounding soils and in the bedrock. It also depends on how often the lake water comes in contact with these minerals.

If a lake gets groundwater from aquifers containing limestone minerals such as calcium carbonate (CaCO_3) or dolomite (CaMgCO_3), alkalinity will be high. The median alkalinity in Lake County lakes (162 mg/L) is considered moderately hard according to the hardness classification scale of Brown, Skougstad and Fishman (1970). Because hard water (alkaline) lakes often have watersheds with fertile soils that add nutrients to the water, they usually produce more fish and aquatic plants than soft water lakes. Since the majority of Lake County lakes have a high alkalinity they are able to buffer the adverse effects of acid rain.

Conductivity and Chloride:

Conductivity is the inverse measure of the resistance of lake water to an electric flow. This means that the higher the conductivity, the more easily an electric current is able to flow through water. Since electric currents travel along ions in water, the more chemical ions or dissolved salts a body of water contains, the higher the conductivity will be. Accordingly, conductivity has been correlated to total dissolved solids and chloride ions. The amount of dissolved solids or conductivity of a lake is dependent on the lake and watershed geology, the size of the watershed flowing into the lake, the land uses within that watershed, and evaporation and bacterial activity. Many Lake County lakes have elevated conductivity levels in May, but not during any other month. This was because chloride, in the form of road salt, was washing into the lakes with spring rains, increasing conductivity. Most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts. Beginning in 2004, chloride concentrations are one of the parameters measured during the lake studies. Increased chloride concentrations may have a negative impact on aquatic organisms. Conductivity changes occur seasonally and with depth. For example, in stratified lakes the conductivity normally increases in the hypolimnion as bacterial decomposition converts organic materials to bicarbonate and carbonate ions depending on the pH of the water. These newly created ions increase the conductivity and total dissolved solids. Over the long term, conductivity is a good indicator of potential watershed or lake problems if an increasing trend is noted over a period of years. It is also important to know the conductivity of the water when fishery assessments are conducted, as electroshocking requires a high enough conductivity to properly stun the fish, but not too high as to cause injury or death.

pH:

pH is the measurement of hydrogen ion (H^+) activity in water. The pH of pure water is neutral at 7 and is considered acidic at levels below 7 and basic at levels above 7. Low pH levels of 4-5 are toxic to most aquatic life, while high pH levels (9-10) are not only toxic to aquatic life but may also result in the release of phosphorus from lake sediment. The presence of high plant densities can increase pH levels through photosynthesis, and lakes dominated by a large amount of plants or algae can experience large fluctuations in pH levels from day to night, depending on the rates of photosynthesis and respiration. Few, if any pH problems exist in Lake County lakes.

Typically, the flooded gravel mines in the county are more acidic than the glacial lakes as they have less biological activity, but do not usually drop below pH levels of 7. The median near surface pH value of Lake County lakes is 8.32, with a minimum of 7.06 in Deer Lake and a maximum of 10.28 in Round Lake Marsh North.

Eutrophication and Trophic State Index:

The word *eutrophication* comes from a Greek word meaning “well nourished.” This also describes the process in which a lake becomes enriched with nutrients. Over time, this is a lake’s natural aging process, as it slowly fills in with eroded materials from the surrounding watershed and with decaying plants. If no human impacts disturb the watershed or the lake, natural eutrophication can take thousands of years. However, human activities on a lake or in the watershed accelerate this process by resulting in rapid soil erosion and heavy phosphorus inputs. This accelerated aging process on a lake is referred to as cultural eutrophication. The term trophic state refers to the amount of nutrient enrichment within a lake system. *Oligotrophic* lakes are usually deep and clear with low nutrient levels, little plant growth and a limited fishery. *Mesotrophic* lakes are more biologically productive than oligotrophic lakes and have moderate nutrient levels and more plant growth. A lake labeled as *eutrophic* is high in nutrients and can support high plant densities and large fish populations. Water clarity is typically poorer than oligotrophic or mesotrophic lakes and dissolved oxygen problems may be present. A *hypereutrophic* lake has excessive nutrients, resulting in nuisance plant or algae growth. These lakes are often pea-soup green, with poor water clarity. Low dissolved oxygen may also be a problem, with fish kills occurring in shallow, hypereutrophic lakes more often than less enriched lakes. As a result, rough fish (tolerant of low dissolved oxygen levels) dominate the fish community of many hypereutrophic lakes. The categorization of a lake into a certain trophic state should not be viewed as a “good to bad” categorization, as most lake residents rate their lake based on desired usage. For example, a fisherman would consider a plant-dominated, clear lake to be desirable, while a water-skier might prefer a turbid lake devoid of plants. Most lakes in Lake County are eutrophic or hypereutrophic. This is primarily as a result of cultural eutrophication. However, due to the fertile soil in this area, many lakes (especially man-made) may have started out under eutrophic conditions and will never attain even mesotrophic conditions, regardless of any amount of money put into the management options. This is not an excuse to allow a lake to continue to deteriorate, but may serve as a reality check for lake owners attempting to create unrealistic conditions in their lakes.

The Trophic State Index (TSI) is an index which attaches a score to a lake based on its average

total phosphorus concentration, its average Secchi depth (water transparency) and/or its average chlorophyll *a* concentration (which represent algae biomass). It is based on the principle that as phosphorus levels increase, chlorophyll *a* concentrations increase and Secchi depth decreases. The higher the TSI score, the more nutrient-rich a lake is, and once a score is obtained, the lake can then be designated as oligotrophic, mesotrophic or eutrophic. Table 1 (below) illustrates the Trophic State Index using phosphorus concentration and Secchi depth.

Table 1. Trophic State Index (TSI).

Trophic State	TSI score	Total Phosphorus (mg/L)	Secchi Depth (feet)
Oligotrophic	<40	≤ 0.012	>13.12
Mesotrophic	$\geq 40 < 50$	$> 0.012 \leq 0.024$	$\geq 6.56 < 13.12$
Eutrophic	$\geq 50 < 70$	$> 0.024 \leq 0.096$	$\geq 1.64 < 6.56$
Hypereutrophic	≥ 70	> 0.096	< 1.64

**APPENDIX D. WATER QUALITY STATISTICS FOR ALL LAKE
COUNTY LAKES.**

2000 - 2008 Water Quality Parameters, Statistics Summary

	ALKoxic <=3ft00-2008		ALKanoxic 2000-2008	
Average	167		202	
Median	162		194	
Minimum	65	IMC	103	Heron Pond
Maximum	330	Flint Lake	470	Lake Marie
STD	42		50	
n =	802		243	

	Condoxic <=3ft00-2008		Condanoxic 2000-2008	
Average	0.8934		1.0312	
Median	0.8195		0.8695	
Minimum	0.2542	Broberg Marsh	0.3210	Lake Kathryn
Maximum	6.8920	IMC	7.4080	IMC
STD	0.5250		0.7985	
n =	806		243	

	NO3-N, Nitrate+Nitrite,oxic <=3ft00-2008		NH3- Nanoxic 2000-2008	
Average	0.508		2.192	
Median	0.156		1.630	
Minimum	<0.05	*ND	<0.1	*ND
Maximum	9.670	South Churchill Lake	18.400	Taylor Lake
STD	1.073		2.343	
n =	807		243	

*ND = Many lakes had non-detects (74.1%)

*ND = 19.8% Non-detects from 28 different lakes

Only compare lakes with detectable concentrations to the statistics above
Beginning in 2006, Nitrate+Nitrite was measured.

	pHoxic <=3ft00-2008		pHanoxic 2000-2008	
Average	8.32		7.28	
Median	8.32		7.28	
Minimum	7.07	Bittersweet #13 Round Lake Marsh North	6.24	Banana Pond
Maximum	10.28		8.48	Heron Pond
STD	0.44		0.42	
n =	801		243	

	All Secchi 2000-2008	
Average	4.51	
Median	3.12	
Minimum	0.33	Fairfield Marsh, Patski Pon
Maximum	24.77	West Loon Lake
STD	3.78	
n =	749	



2000 - 2008 Water Quality Parameters, Statistics Summary (continued)

	TKNoxic <=3ft00-2008	
Average	1.450	
Median	1.200	
Minimum	<0.1	*ND
Maximum	10.300	Fairfield Marsh
STD	0.845	
n =	802	

*ND = 3.9% Non-detects from 15 different lakes

	TKNanoxic 2000-2008	
Average	2.973	
Median	2.330	
Minimum	<0.5	*ND
Maximum	21.000	Taylor Lake
STD	2.324	
n =	243	

*ND = 2.9% Non-detects from 4 different lakes

	TPoxic <=3ft00-2008	
Average	0.105	
Median	0.065	
Minimum	<0.01	*ND
Maximum	3.880	Albert Lake
STD	0.218	
n =	808	

*ND = 2.6% Non-detects from 9 different lakes

	TPanoxic 2000-2008	
Average	0.316	
Median	0.181	
Minimum	0.012	Independ. Grove
Maximum	3.800	Taylor Lake
STD	0.419	
n =	243	

	TSSall <=3ft00-2008	
Average	15.5	
Median	8.2	
Minimum	<0.1	*ND
Maximum	165.0	Fairfield Marsh
STD	20.3	
n =	813	

*ND = 1.5% Non-detects from 9 different lakes

	TVSoxic <=3ft00-2008	
Average	132.8	
Median	129.0	
Minimum	34.0	Pulaski Pond
Maximum	298.0	Fairfield Marsh
STD	39.8	
n =	757	

No 2002 IEPA Chain Lakes

	TDSoxic <=3ft00-2004	
Average	470	
Median	454	
Minimum	150	Lake Kathryn, White
Maximum	1340	IMC
STD	169	
n =	745	

No 2002 IEPA Chain Lakes.

	CLanoxic <=3ft00-2008	
Average	234	
Median	139	
Minimum	41	Timber Lake (N)
Maximum	2390	IMC
STD	364	
n =	125	

	CLoxic <=3ft00-2008	
Average	210	
Median	166	
Minimum	30	White Lake
Maximum	2760	IMC
STD	233	
n =	470	

Anoxic conditions are defined ≤ 1 mg/l D.O.
pH Units are equal to the -Log of [H] ion activity
Conductivity units are in MilliSiemens/cm
Secchi Disk depth units are in feet
All others are in mg/L

Minimums and maximums are based on data from all lakes from 2000-2008 (n=1351).

Average, median and STD are based on data from the most recent water quality sampling year for each lake.

LCHD Lakes Management Unit ~ 12/1/2008

APPENDIX E. GRANT PROGRAM OPPORTUNITES.

Table E1. Potential Grant Opportunities

Grant Program Name	Funding Source	Contact Information	Funding Focus				Cost Share
			Water Quality/ Wetland	Habitat	Erosion	Flooding	
Challenge Grant Program	USFWS	847-381-2253 or 309-793-5800		X	X		
Chicago Wilderness Small Grants	CW	312-346-8166 ext. 30					None
Partners in Conservation (formerly C2000)	IDNR	http://dnr.state.il.us/orep/c2000/		X			None
Conservation Reserve Program	NRCS	http://www.nrcs.usda.gov/programs/crp/		X			Land
Ecosystems Program	IDNR	http://dnr.state.il.us/orep/c2000/ecosystem/		X			None
Emergency Watershed Protection	NRCS	http://www.nrcs.usda.gov/programs/ewp/			X	X	None
Five Star Challenge	NFWF	http://www.nfwf.org/AM/Template.cfm		X			None
Illinois Flood Mitigation Assistance Program	IEMA	http://www.state.il.us/iema/construction.htm				X	None
Great Lakes Basin Program	GLBP	http://www.glc.org/basin/stateproj.html?st=il	X		X		None
Illinois Clean Energy Community Foundation	ICECF	http://www.illinoiscleanenergy.org/		X			
Illinois Clean Lakes Program	IEPA	http://www.epa.state.il.us/water/financial-assistance/index.html					None
Lake Education Assistance Program (LEAP)	IEPA	http://www.epa.state.il.us/water/conservation-2000/leap/index.html	X				\$500

CW = Chicago Wilderness
 ICECF = Illinois Clean Energy Community Foundation
 IEMA = Illinois Emergency Management Agency
 IEPA = Illinois Environmental Protection Agency
 IDNR = Illinois Department of Natural Resources
 IDOA = Illinois Department of Agriculture
 LCSMC = Lake County Stormwater Management Commission
 LCSWCD = Lake County Soil and Water Conservation District
 NFWF = National Fish and Wildlife Foundation
 NRCS = Natural Resources Conservation Service
 USACE = United States Army Corps of Engineers
 USFWS = United States Fish and Wildlife Service

Table E1. Continued

Grant Program Name	Funding Source	Contact Information	Funding Focus				Cost Share
			Water Quality/ Wetland	Habitat	Erosion	Flooding	
Northeast Illinois Wetland Conservation Account	USFWF	847-381-2253	X				
Partners for Fish and Wildlife	USFWS	http://ecos.fws.gov/partners/		X			> 50%
River Network's Watershed Assistance Grants Program	River Network	http://www.rivernetwork.org	X	X	X		na
Section 206: Aquatic Ecosystems Restoration	USACE	312-353-6400, 309-794-5590 or 314-331-8404		X			35%
Section 319: Non-Point Source Management Program	IEPA	http://www.epa.state.il.us/water/financial-assistance/non-point.html	X	X			>40%
Section 1135: Project Modifications for the Improvement of the Environment	USACE	312-353-6400, 309-794-5590 or 314-331-8404		X			25%
Stream Cleanup And Lakeshore Enhancement (SCALE)	IEPA	http://www.epa.state.il.us/water/watershed/scale.html	X	X			None
Streambank Stabilization & Restoration (SSRP)	IDOA/ LCSWCD	http://www.agr.state.il.us/Environment/conserv/ or call LCSWCD at (847) 223-1056		X	X		25%
Watershed Management Boards	LCSMC	http://www.co.lake.il.us/smc/projects/wmb/default.asp	X		X	X	50%
Wetlands Reserve Program	NRCS	http://www.nrcs.usda.gov/programs/wrp/	X	X			Land
Wildlife Habitat Incentive Program	NRCS	http://www.nrcs.usda.gov/programs/whip/		X			Land

CW = Chicago Wilderness
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 IDOA = Illinois Department of Agriculture
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